

Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Geostationary Lightning Mapper (GLM)

Statement of Work (SOW)

July 25, 2005

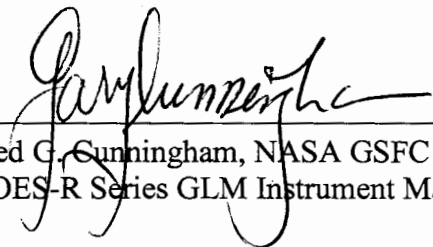


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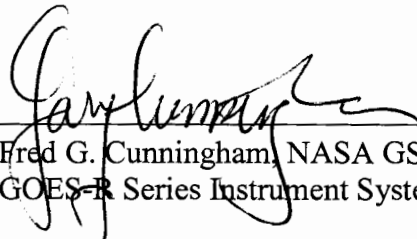
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GOES-R Series
Geostationary Lightning Mapper (GLM)
Statement of Work (SOW)

Prepared By:

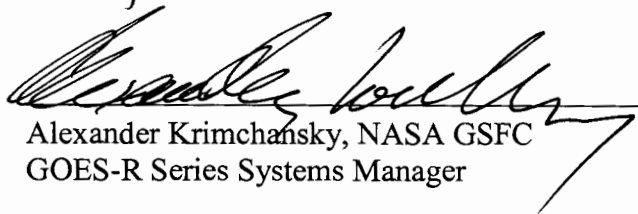

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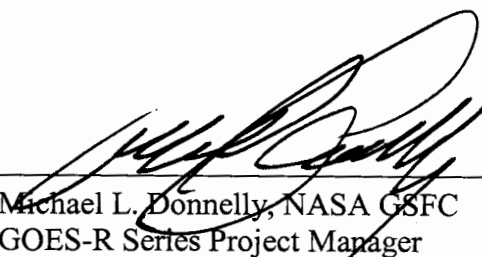

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/GLM

GLM SOW

417-R-GLMSOW-0059, RM Version 0.0, GOES Lightning Mapper (GLM) Statement of Work (SOW)

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GLMSOW1	1	1 Scope
GLMSOW2	1.0-1	<p>The acquisition of the Geostationary Lightning Mapper (GLM) will follow a phased development strategy and will include two major phases: Formulation and Implementation. The work completed under this Statement of Work (SOW) for the Formulation Phase will be used as the foundation for the implementation contract to be awarded following completion of formulation.</p> <p>This SOW specifies the requirements imposed on the vendors for performing work to complete the Formulation Phase of the GLM development.</p>
GLMSOW3	1.1	1.1 Introduction
GLMSOW4	1.1.0-1	<p>The GLM is a single channel, visible imager used to measure total lightning activity over the full-disk as part of a 3-axis stabilized, geostationary weather satellite system.</p> <p>The GLM objectives are as follows:</p> <ul style="list-style-type: none"> • Provide continuous, full-disk lightning measurements for storm warning and nowcasting. • Provide an early warning of tornadic activity. • Accumulate a long-term database to track decadal changes. <p>The Formulation Phase of the GLM development includes studies of both the minimum operational performance (threshold) requirements of the GLM tasks, as well as goal performance requirements.</p>
GLMSOW5	1.1.0-2	The Contractor shall give first priority to meeting the threshold requirements, and then address the goal requirements.
GLMSOW6	1.1.0-3	The Contractor shall assess the resources (size, mass, power, data rate, risk and cost) of meeting the threshold requirements and present the results at the MTR.
GLMSOW7	1.1.0-4	For each of the ranges from the threshold to the goal values specified in the requirements document, the Contractor shall address the implications (size, mass, power, data rate, risk, schedule and cost) of moving toward or meeting the goal requirements and present the results at the MTR.
GLMSOW8	1.2	1.2 Definitions
GLMSOW9	1.2.0-1	<p>In the context of this SOW:</p> <p>The term <i>Configuration</i> refers to the packaging of the GLM; e.g., a single-telescope instrument, a two-telescope instrument and a four-telescope instrument. Separate electronics box(s), or internal electronics are a part of the configuration. It includes the modularity of subsystems and components and whether or not, or how, future performance enhancements can be incorporated.</p> <p>The Contractor is free to study any combination but must define the ‘configuration’ for clarity.</p> <p>The term Approach refers to the methodology to be employed by the Contractor to meet the requirements of this SOW.</p>

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GLMSOW10	2	2 Applicable Documents
GLMSOW11	2.0-1	<ul style="list-style-type: none">• 417-R-GLMPORD - 0057: GLM Performance and Operations Requirements Document (PORD)• 417-R-GLMUIID - 0058: GLM Unique Instrument Interface Document (UIID)• 417-R-GIRD-0009: GOES-R General Interface Requirements Document (GIRD)• 417-R-IMAR - 0012: Instrument Mission Assurance Requirements Document (IMAR)• 417-R-RPT-0027: The Radiation Environment for Electronic Devices on the GOES-R Series Satellites
GLMSOW12	2.1	2.1 Reference Documents
GLMSOW13	2.1.0-1	<ul style="list-style-type: none">• NASA NPR 8000.4: Risk Management Procedures and Guidelines (4/13/04)

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GLMSOW14	3	3 Formulation Phase Reviews
GLMSOW15	3.0-1	The Contractor shall perform the reviews and reporting tasks listed below.
GLMSOW16	3.0-2	The Contractor shall provide deliverable products as specified below.
GLMSOW17	3.0-3	The Contractor shall provide at each review the status of SOW items completed.
GLMSOW18	3.0-4	For all reviews the Contractor shall augment the presentation sheets with facing page narrative.
GLMSOW19	3.0-5	The format of the reviews will provide breaks for caucuses of the Government review team; mid-morning, mid-afternoon and following the formal presentation. The caucuses will be used to review the presentation and generate comments and questions for the Contractor, and to answer questions submitted by the Contractor that could not be answered from the floor. Questions that cannot be answered at the review by either party will be submitted in writing following the review. Specific Action Items (AIs) or Government Requests for Action (RFAs) or Requests for Information (RFIs), that require extended time for response, may be generated at any review or by the Government at any time. After contract award, the Government will work with the Contractor to establish the review schedule to avoid conflicts with holidays and other commitments. At that time the delivery schedule in the contract may be adjusted.
GLMSOW20	3.1	3.1 Kick-Off and Requirements Review
GLMSOW21	3.1.0-1	A one-day kick-off meeting will be held at the Contractor's facility in accordance with the delivery schedule set forth in the contract.
GLMSOW22	3.1.0-2	At this review:
GLMSOW23	3.1.0-3	The Contractor shall describe the strawman or basis of assumptions that serve as the starting point for the trade studies and systems analyses.
GLMSOW24	3.1.0-4	The Contractor shall address the Requirements Traceability tool to be used for formulation and the implementation of the GLM development.
GLMSOW25	3.1.0-5	The Contractor shall provide to the Government the draft System Engineering Management Plan for formulation.
GLMSOW26	3.1.0-6	The Contractor shall provide an outline of the planned formulation schedule with milestones.
GLMSOW27	3.1.0-7	The Government will provide clarification of items in the PORD, GIRD, UIID and SOW to written questions received after contract start.
GLMSOW28	3.1.0-8	The Contractor shall provide a detailed Technology Readiness Plan to be carried out during the formulation phase to validate all technologies not deemed to be ready for the implementation phase.
GLMSOW29	3.1.0-9	The Contractor shall provide and implement a Risk Management Plan (RMP). NASA NPG 8000.4 may be used as a guide.
GLMSOW30	3.1.0-10	The Government will evaluate the draft plans and provide comment following the meeting.
GLMSOW31	3.2	3.2 Progress Reviews
GLMSOW32	3.2.0-1	As provided in Section B of the Contract, there will be two, one-day Progress Reviews (PRs) held at the Contractor's facility, in accordance with the schedule presented in the contract.

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GLMSOW33	3.2.0-2	The review agenda will be established jointly by the Government and the Contractor.
GLMSOW34	3.2.0-3	The Contractor shall submit the agenda one week prior to the review, and the Government will add additional items to be addressed, if any.
GLMSOW35	3.2.0-4	At this review:
GLMSOW36	3.2.0-5	The Contractor shall present the results of the work performed since the previous review.
GLMSOW37	3.2.0-6	The Contractor shall discuss relevant technical and programmatic issues and findings, and describe the progress of the concept design.
GLMSOW41	3.3	3.3 Midterm Review
GLMSOW42	3.3.0-1	The Midterm Review (MTR) will be a two-day review held at the Contractor's facility in accordance with the delivery schedule set forth in the contract.
GLMSOW43	3.3.0-2	The Contractor shall submit the draft MTR Data Package (MTR Report) in electronic format seven (7) days prior to the review, and the full presentation, including a copy in electronic form, at the review.
GLMSOW44	3.3.0-3	At this review:
GLMSOW45	3.3.0-4	The Contractor shall present the initial GLM concepts that were used as the basis for trade studies.
GLMSOW46	3.3.0-5	The Contractor shall present the results of all trade studies and analyses completed to date.
GLMSOW47	3.3.0-6	The Contractor shall address the status and key results to date of all items identified in Section 4.1, 4.1.1, 4.1.2, 4.2, 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.5 and 4.2.6.
GLMSOW48	3.3.0-7	The Contractor shall identify requirements that are redundant or contradictory, and identify those requirements and/or goals that are not achievable due to resource constraints.
GLMSOW49	3.3.0-8	The Contractor shall present the results of the requirements evaluation, with recommended changes designed to either reduce mass, volume, power, data rate, risk or cost, or to increase performance.
GLMSOW50	3.3.0-9	The Contractor shall review all requirements documents and recommend final specification values for all requirements identified as TBR and TBD.
GLMSOW51	3.3.0-10	The Contractor shall present a draft recommended Work Breakdown Structure for the implementation phase.
GLMSOW52	3.3.0-11	The Contractor shall provide a draft schedule for the implementation phase.
GLMSOW53	3.3.0-12	The Contractor shall identify the flight instruments that can be considered as heritage instruments.
GLMSOW54	3.3.0-13	The Contractor shall identify the features in heritage instruments that can be used to reduce risk in the GLM development.
GLMSOW55	3.3.0-14	The Contractor shall discuss in detail the technical and programmatic risks and mitigation approaches associated with the implementation of the GLM.
...		<p>This discussion includes:</p> <ul style="list-style-type: none"> • Fabrication, Integration and Test. • Calibration

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GLMSOW55	3.3.0-14	<ul style="list-style-type: none"> • Certification of Mission Life Issues • Long Term Stability • Development Lead Times, Performance and Life History of Heritage Designs. • De-scope options.
GLMSOW56	3.3.0-15	The Contractor shall deliver final System Engineering Management, Risk Management, and Technology Readiness Plans for formulation.
GLMSOW57	3.3.0-16	The Contractor shall present a draft cost estimate by WBS with a confidence factor on the estimate.
GLMSOW58	3.3.0-17	The Government will release the final requirements approximately one month following the MTR.
GLMSOW59	3.3.0-18	Following release of the final requirements the Government will answer any clarification questions provided the questions are submitted in writing.
GLMSOW60	3.3.0-19	Contractors shall submit their questions to the Government within two weeks after release of final requirements. Responses to the questions will be provided to all formulation contractors.
GLMSOW61	3.4	3.4 Formulation Phase Concept and Cost Review
GLMSOW62	3.4.0-1	The Formulation Phase Concept and Cost Review (FPCCR) will be a three-day review held at the Contractor's facility in accordance with the delivery schedule set forth in the contract.
GLMSOW63	3.4.0-2	The Contractor shall submit the FPCCR draft Data Package in electronic format 1 week prior to the review.
GLMSOW64	3.4.0-3	At this review:
GLMSOW65	3.4.0-4	The Contractor shall present the results of the work performed under the contract.
GLMSOW66	3.4.0-5	The Contractor shall present a summary of all analyses and trade studies.
GLMSOW67	3.4.0-6	The Contractor shall present the Concept Design developed as a result of the formulation studies.
GLMSOW68	3.4.0-7	<p>This discussion shall include:</p> <ul style="list-style-type: none"> • Fabrication, Integration and Test. • Calibration • Certification of Mission Life Issues • Long-Term Stability • Development Lead Times, Performance and Life History of Heritage Designs. • De-scope options.
GLMSOW69	3.4.0-8	The Contractor shall present (in a separate document) a final estimate of costs with a confidence factor on the estimate for implementation based on the Work Breakdown Structure (WBS) provided by the Government. The cost information will not be presented at the open review, just an overview of the process.
GLMSOW70	3.4.0-9	The Contractor shall convene a splinter review, following the FPCCR, to discuss the cost information with Project Management.
GLMSOW71	3.4.0-10	The Contractor shall discuss and deliver to the Government the draft version of those plans to be used during the Implementation Phase that are listed on the Document Delivery List.
GLMSOW72	3.4.0-11	The Contractor shall address all topics listed in Section 4.3 through 4.5 of this SOW.

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GLMSOW73	3.5	3.5 Action Item Review	
GLMSOW74	3.5.0-1	The Action Item Review (AIR), to be held at the Goddard Space Flight Center, will be a one-day review held in accordance with the delivery schedule set forth in the contract. The AIR will be the final event in the formulation study and will be used to wrap up any action items or other issues remaining after the FPCCR.	
GLMSOW75	3.5.0-2	The Contractor shall present closure to Action Items (AIs) remaining from the FPCCR.	
GLMSOW76	3.5.0-3	The Government will provide additional clarification of the final requirements, if needed, provided the question(s) have been submitted in writing prior to the AIR. The question(s) along with answers will be distributed to all Contractors.	
GLMSOW77	3.5.0-4	At the AIR the Government will identify residual weaknesses found in the Concept Design, draft implementation plans, trade studies and analyses.	
GLMSOW78	3.6	3.6 Final Report Package	
GLMSOW79	3.6.0-1	The Final Report Package will consist of: The FPCCR viewgraphs with comprehensive facing page text. Additional material that is not presented at the FPCCR Review may be appended if the study contractor so desires. A compilation of all deliverable products that document the work performed under the Formulation Phase Contract.	
GLMSOW80	3.7	3.7 Contract Deliverables	
GLMSOW81	3.7.1	3.7.1 Document Delivery	
GLMSOW82	3.7.1.0-1	The Contractor shall deliver the following documents as specified.	
		Deliverable Item	Delivery Date
		Draft Systems Engineering Management Plan - formulation	At Kick-off Review
		Risk Management Plan	At Kick-off Review
		Technology Readiness Plan	At Kick-off Review
		Formulation Schedule with Milestones	At Kick-off Review
		Master Action Item Data Base - start ACA*	As updated
		Requirements Traceability Matrix	At MTR
		Decision Matrix	At MTR
		Systems Engineering Management Plan	At MTR
		Draft Mid Term Review Data Package	1 week before MTR
		Final Mid Term Review Data Package	At the MTR
		Recommended Work Breakdown Structure - Implementation	At MTR
		Implementation Phase Schedule, draft	At MTR
		Preliminary Cost Estimate	At MTR
		System Performance Verification Plan, draft - implementation	At FPCCR
		Project Management Plan, draft - implementation	At FPCCR
		Draft FPCCR Package	1 week before FPCCR
		Final FPCCR Package	At FPCCR
		Concept Design presentation	At FPCCR
		Cost Estimates	At FPCCR
		Updated Implementation Phase Schedule, draft	At FPCCR
		Final Report package	At AIR
GLMSOW83	3.7.2	3.7.2 Acceptance of Contract Deliverable Items	
GLMSOW84	3.7.2.0-1	The Contracting Officer's written determination that Government Requests For Action (RFAs), Request For Information (RFIs), other Action Item (AI) closures, and other deliverable reviews and products, have been closed out or completed will constitute acceptance of the deliverable.	

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GLMSOW85	3.8	3.8 Contractor Web Page
GLMSOW86	3.8.0-1	The Contractor shall establish a secure web site, with remote access by the Government for retrieval of required documents, e.g., Technical Analyses, System Trade Study Reports, data packages, etc., and for exchange of other competition sensitive information.

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GLMSOW87	4	4 Formulation Tasks
GLMSOW88	4.0-1	The Formulation Phase is partitioned into three segments: Segment one ends with the MTR, segment two ends with the FPCCR, and segment three ends with the AIR.
GLMSOW89	4.0-2	<p>The Contractor shall complete the following three segments of study that comprise the Formulation Phase of the GLM development:</p> <ul style="list-style-type: none"> • Systems Requirements Analysis, System Trade and Requirements Baseline Studies • Conceptual Design of a GLM instrument • Closeout with AIR
GLMSOW90	4.0-3	<p>The Formulation Phase requires both technical as well as program management effort and will result in a final definition of requirements and the submission of a concept design that may be the basis of the contractor's implementation proposal.</p> <p>The intent of segment 1 of the study is to determine the feasibility of meeting the threshold requirements of the GLM PORD, and the implications of the goal requirements and their impact on instrument mass, volume, power, data rate, associated risks and cost. These studies are designed to enable the Government to: (1) Update and refine mission requirements throughout the sequence of scheduled reviews; and (2) issue final requirements approximately one month following the completion of the MTR. The intent of segment 2 is to provide concept designs for potential implementation from each contractor. Segment 3 closes out the formulation phase with closure of Action Items and identification of weaknesses to each contractor.</p>
GLMSOW91	4.1	4.1 Systems Engineering
GLMSOW92	4.1.0-1	The Contractor shall use a disciplined Systems Engineering Process (SEP) for the performance of all tasks within this SOW.
GLMSOW93	4.1.0-2	The Contractor shall develop and implement a systems engineering management process and document the process within a Systems Engineering Management Plan (SEMP) to complete the Formulation Phase.
GLMSOW94	4.1.0-3	<p>The SEMP shall define the necessary tasks and activities to be performed to complete the following systems engineering tasks:</p> <ul style="list-style-type: none"> • Requirements analysis and traceability • Functional analysis, allocation and derivation • Synthesis for the system Concept Design.
GLMSOW95	4.1.0-4	<p>The Contractor shall use the SEP to transform the requirements stipulated in the PORD, GIRD, UIID and IMAR into a design process that addresses the following elements for the Concept Design:</p> <ul style="list-style-type: none"> • Systems design • Systems development • System fabrication • System test, evaluation and calibration • Operational deployment
GLMSOW96	4.1.1	4.1.1 System Requirements Analysis
GLMSOW97	4.1.1.0-1	The Contractor shall utilize a requirements traceability tool to track the flow down of requirements to the subsystem or lower level. The GOES-R Project is using DOORS.

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GLMSOW98	4.1.1.0-2	<p>The Contractor's Systems Requirements Analysis shall address the following general requirements:</p> <ul style="list-style-type: none"> • Analysis of the GLM mission, performance, technical, operational and interface requirements as stated in the PORD, GIRD, UIID and IMAR; • Development of a Traceability Matrix of all requirements from the PORD, GIRD, UIID and IMAR to the Contractors derived and allocated requirements for the GLM Instrument; • Development of a Decision Matrix with an audit trail from requirements to analysis to Concept Design, including key decisions made and their rationale; • Development of a verification and validation methodology designed to demonstrate that the Concept Design meets requirements; • Development and maintenance of a Master Action Item Database (MAID) listing all RFAs from formal reviews, Government status reviews, internal technical reviews, peer reviews, and telecons, listing author of the RFA, person responsible for closure, wording of the RFA, response, person(s) authorizing final closure, and date closed. The update frequency of the MAID will depend upon the level of activity, with a nominal update of once per month. The MAID will be carried forward into the implementation phase.
GLMSOW99	4.1.1.0-3	The Contractor shall conduct trade studies, trade-off analyses, risk analyses and cost-effectiveness analyses to ensure that a thorough and comprehensive set of options and alternatives is considered and analyzed for design, with consideration for all aspects of the system life cycle and all aspects of system life cycle cost.
GLMSOW100	4.1.1.0-4	The Contractor shall identify the schedule, cost, and risk drivers of the instrument design requirements.
GLMSOW101	4.1.1.0-5	The Contractor shall evaluate all requirements and recommend at the MTR modifications that would significantly reduce the size, mass, power, data rate, technical concerns, associated risks, and costs.
GLMSOW102	4.1.1.0-6	The Contractor shall evaluate all requirements, in the range between threshold and goals, in terms of performance, risk, and system resources.
GLMSOW103	4.1.1.0-7	The Contractor shall propose requirement values, and the associated rationale, for all parameters listed as "TBD" or "TBR" within the GLM requirements documents, NLT the MTR.
GLMSOW104	4.1.1.0-8	The Contractor shall quantify potential cost impacts of the recommended requirements changes, on an absolute and relative cost basis, measured in FY 2004 dollars.
GLMSOW105	4.1.2	4.1.2 Trade Studies and General Analyses
GLMSOW106	4.1.2.0-1	The Contractor shall perform the trade studies listed below and other trade studies as the Contractor chooses, necessary for proof of the concept design.
GLMSOW107	4.1.2.0-2	<p>The Contractor shall include the following information in each Trade Study Report:</p> <ul style="list-style-type: none"> • Evaluation of how the trade-offs impact potential GLM design concepts; • Evaluation of technical performance, schedule and cost risks; • Evaluation of impact on system mass, power, volume and data rate.
GLMSOW108	4.1.2.0-3	The Contractor shall complete all trade studies required by the contract prior to the MTR.
GLMSOW109	4.1.2.0-4	The Government reserves the right to add additional trades and analyses as formulation progresses.
GLMSOW110	4.1.3	4.1.3 PDRR Contractor Support

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GLMSOW111	4.1.3.0-1	<p>The Contractor shall provide support to up to three PDRR vendors as outlined below:</p> <ul style="list-style-type: none"> • Support up to two, one day meetings with each of the PDRR vendors in the time frame MTR - end of contract to address questions regarding interface issues, accommodation issues, ground data processing, and to provide, when available, mechanical and thermal models, et cetera. It will also provide a forum for the Contractor to ask approved questions of the PDRR vendors. <ul style="list-style-type: none"> • Meetings will be chaired by Government personnel who will determine the appropriateness of each question prior to discussion • It is suggested that the Contractor negotiate a Non-disclosure Agreement with each of the up to three PDRR vendors, but not enter exclusive agreements with any.
GLMSOW112	4.2	4.2 Trade Studies
GLMSOW113	4.2.1	4.2.1 TS1: Requirements Analysis, System Configuration and Coverage Trade Study
GLMSOW250	4.2.1.0-1	TS1 shall be completed by MTR.
GLMSOW114	4.2.1.1	4.2.1.1 Requirements Analysis
GLMSOW115	4.2.1.1.0-1	The Contractor shall evaluate instrument performance requirements provided in the PORD and determine the feasibility of meeting the threshold requirements.
GLMSOW116	4.2.1.1.0-2	The Contractor shall assess the impact of each of the threshold requirements on risk, cost and the constraints of volume, mass and power.
GLMSOW117	4.2.1.1.0-3	The Contractor shall identify the flight instruments that can be considered as heritage instruments for the GLM, including in-flight performance assessment and lifetime.
GLMSOW118	4.2.1.1.0-4	The Contractor shall recommend requirement relaxations that would significantly mitigate technical, schedule and cost risks.
GLMSOW119	4.2.1.2	4.2.1.2 System Configuration
GLMSOW120	4.2.1.2.0-1	The Contractor shall develop a configuration that is modular in concept that allows for easy integration and change of modules, and provides opportunities for potential technology and performance upgrades.
GLMSOW121	4.2.1.2.0-2	The Contractor shall evaluate configuration and coverage impacts on at least the following: FPA development, data rate, instrument thermal control, external mechanical impulses and jitter.
GLMSOW122	4.2.1.2.0-3	The Contractor shall identify the features in heritage instruments that can be used to reduce risk in the GLM development.
GLMSOW123	4.2.1.2.0-4	The Contractor shall evaluate the pointing accuracy of the instrument and its sensitivity to external disturbances as a function of system configuration.
GLMSOW124	4.2.1.2.0-5	The Contractor shall assess the benefits of each configuration and include estimates of volume, mass, power, technical performance, associated risks and costs.
GLMSOW125	4.2.1.3	4.2.1.3 Coverage
GLMSOW126	4.2.1.3.0-1	The Contractor shall determine the optimum configuration to provide continuous, real-time, simultaneous coverage of the defined full-disk area.
GLMSOW127	4.2.1.3.0-2	The Contractor shall define an instrument configuration that would cover a hemisphere , north-to-south or east-to-west and produce a cost delta between this approach and full-disk coverage.

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GLMSOW128	4.2.1.3.0-3	The Contractor shall define an instrument that covers CONUS and surrounding area only, and produce a cost delta between this approach and full-disk coverage.
GLMSOW129	4.2.2	4.2.2 TS2: Solar Intrusion Trade Study
GLMSOW130	4.2.2.0-1	The Contractor shall evaluate the performance of the instrument in the event of solar intrusion onto the primary optic or onto the focal plane during routine measurements.
GLMSOW131	4.2.2.0-2	The Contractor shall evaluate the optimum disk coverage area to preclude solar intrusion.
GLMSOW132	4.2.2.0-3	The Contractor shall evaluate the impact on instrument configuration and performance of operating through eclipses.
GLMSOW133	4.2.2.0-4	The Contractor shall evaluate the impact on performance and safety of solar intrusion during anomalous conditions as defined in the GIRD, section 3.1.2.3 (On-Orbit Operational Concept).
GLMSOW134	4.2.2.0-5	The Contractor shall evaluate the impact of stray light on detection efficiency and false alarm rate.
GLMSOW135	4.2.2.0-6	The Contractor shall evaluate the impact of prolonged solar illumination on the optics and radiators when the instrument is off or in the safe hold made.
GLMSOW136	4.2.3	4.2.3 TS3: Focal Plane Architecture Trade Study
GLMSOW137	4.2.3.0-1	The Contractor shall evaluate focal plane architectures to optimize instrument performance at the lowest cost and risk.
GLMSOW138	4.2.4	4.2.4 TS4: Ground Truth Verification Study
GLMSOW139	4.2.4.0-1	The Contractor shall develop a concept to verify lightning detection against ground truth observations.
GLMSOW140	4.2.4.0-2	The plan shall address sources, cost, availability and processing of the ground truth data.
GLMSOW141	4.2.4.0-3	The plan shall address the adequacy of the data for verifying the detection and false alarm rates specified in the PORD.
GLMSOW142	4.2.5	4.2.5 TS5: Yaw Flip Accommodation
GLMSOW143	4.2.5.0-1	The Contractor shall evaluate instrument performance and accommodation of a semi-annual observatory yaw flip maneuver as it impacts coverage area, navigation, and instrument orientation on the spacecraft.
GLMSOW144	4.2.6	4.2.6 TS6: Additional trade studies as proposed by the Contractor
GLMSOW145	4.2.6.0-1	If the Contractor intends to propose additional trade studies as an enhancement to the contract, these trades shall be incorporated in Attachment G of the Contract.
GLMSOW146	4.3	4.3 Concept Design
GLMSOW147	4.3.1	4.3.1 Tool Development
GLMSOW148	4.3.1.0-1	The Contractor shall use the tool to demonstrate that the GLM conceptual design meets all requirements.
GLMSOW149	4.3.1.0-2	The Contractor shall develop simulations and analytical tools in support of the conceptual design and trade study effort.

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GLMSOW150	4.3.1.0-3	The Contractor shall use these tools throughout the GLM Formulation and Implementation Phases.
GLMSOW151	4.3.1.0-4	It is the intention of the government to make these analytical tools, simulations and models deliverable items early in the implementation phase by the selected GLM Contractor, and to have these tools supported and updated by the GLM Contractor throughout the implementation phase.
GLMSOW152	4.3.2	4.3.2 Simulation
GLMSOW153	4.3.2.0-1	The Contractor shall use the simulation tools to demonstrate that the expected performance of the Concept Design meets performance requirements.
GLMSOW154	4.3.2.0-2	<p>The Contractor shall include in the simulation models of GLM:</p> <ul style="list-style-type: none"> • Spatial resolution • Temporal resolution • Geolocation algorithm • Calibration • Lightning detection algorithm • Dynamic range • On-board data processing • Thermal distortion • Detector artifacts • Spacecraft to instrument disturbance transfer functions • Orbit and Attitude Errors
GLMSOW155	4.3.3	4.3.3 Concept Design and Related Analyses
GLMSOW156	4.3.3.0-1	The Contractor shall develop a Concept Design for GLM addressing all requirements contained in the PORD, GIRD, UIID and IMAR.
GLMSOW157	4.3.3.0-2	<p>The Contractor shall perform engineering analyses to justify design parameters, tolerances, and design/performance margins, and to support required trade studies. The following issues are of particular interest:</p> <ul style="list-style-type: none"> • Geo-location accuracy • Optimal spatial resolution • Achievable detection efficiency • False alarm rate • Optimum sample rate and integration time • Dynamic range with maximum daylight background • Practical limits on area coverage • Detector susceptibility to the geo-synchronous radiation environment. • Electronics susceptibility to single-event-upsets and permanent damage due to the geo-synchronous radiation environment • The effect of the geo-synchronous radiation environment on optical performance, e.g., glass darkening and coating degradation • Data latency to spacecraft
GLMSOW158	4.3.3.0-3	The Contractor shall maintain a Government Provided Physical Parameter Sheet (GPPPS) that includes performance, mass and power breakdowns by subsystem and component.
GLMSOW159	4.3.3.0-4	A template of the draft parameter sheet will be provided at the Kick-Off Review.
GLMSOW160	4.3.3.1	4.3.3.1 Mechanical

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GLMSOW161	4.3.3.1.0-1	The Contractor shall provide a preliminary mechanical and structural analysis demonstrating size and mass margins, first mode resonance, instrument sensitivity to dynamic and shock loads, and sensitivity to self and spacecraft induced disturbances.
GLMSOW162	4.3.3.2	4.3.3.2 Power System
GLMSOW163	4.3.3.2.0-1	The Contractor shall provide a preliminary analysis of the power system requirements of the Concept Design.
GLMSOW164	4.3.3.3	4.3.3.3 Command and Telemetry
GLMSOW165	4.3.3.3.0-1	The Contractor shall provide a preliminary analysis of the Command and Telemetry architecture of the Concept Design including onboard memory and stored commands, onboard processing, health and safety, engineering and science data flow.
GLMSOW166	4.3.3.4	4.3.3.4 Thermal
GLMSOW167	4.3.3.4.0-1	The Contractor shall provide a preliminary analysis of the thermal control system showing planned heat flow to the spacecraft and instrument radiators, designed operating temperature range and radiator sizing.
GLMSOW168	4.3.3.4.0-2	The Contractor shall examine electric power dissipation on the focal plane, readout electronics and A/D converters, including thermal conductivity of electrical connections and mechanical supports.
GLMSOW169	4.3.3.4.0-3	The Contractor shall examine the impact of a twice-yearly yaw flip maneuver on instrument resources.
GLMSOW170	4.3.3.4.0-4	The Contractor shall establish permissible deviations from a clear FOV for instrument radiators.
GLMSOW171	4.3.3.5	4.3.3.5 Fault Detection and Correction
GLMSOW172	4.3.3.5.0-1	The Contractor shall provide a preliminary analysis of the Fault Detection and Correction methodology proposed for the Concept Design to prevent failures due to Single Event Upset (SEU) and Single Event Latch-up (SEL) events.
GLMSOW173	4.3.3.6	4.3.3.6 Calibration
GLMSOW174	4.3.3.6.0-1	The Contractor shall define the proposed calibration methodology for the GLM (both pre-launch and post launch).
GLMSOW175	4.3.3.6.0-2	The Contractor shall develop a conceptual design for instrument calibration.
GLMSOW176	4.3.3.7	4.3.3.7 Image Navigation (Geo-location)
GLMSOW177	4.3.3.7.0-1	The Contractor shall define a systems approach for meeting the mission-level navigation (geo-location) requirements specified in the PORD, given the spacecraft interface specification contained in the GIRD and UIID.
GLMSOW178	4.3.3.7.0-2	The Contractor shall include in the scope of the navigation solution a description of all flight hardware and ground processing algorithms required to meet mission-level navigation requirements.
GLMSOW179	4.3.3.7.0-3	The Contractor shall develop navigation error budgets, along with supporting analyses and derived requirements.
GLMSOW180	4.3.3.7.0-4	The Contractor shall discuss requirements for hardware and processing elements related to navigation.

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GLMSOW181	4.3.3.7.0-5	The Contractor shall address the requirement to verify all navigation requirements on-orbit (TBR).
GLMSOW182	4.3.3.8	4.3.3.8 Event Detection and On-board Data Processing
GLMSOW183	4.3.3.8.0-1	The Contractor shall define the Lightning Detection Algorithm(s) (LDA), and the algorithm(s) for level 1B data processing on the ground.
GLMSOW184	4.3.3.8.0-2	The Contractor shall present, at or before the FPCCR, expected performance of these algorithms and the rationale for selection.
GLMSOW185	4.3.3.8.0-3	The Contractor shall define the on-board data processing methodology and provide an estimate of the processing capacity required to implement the LDA.
GLMSOW186	4.3.3.8.0-4	The Contractor shall define the expected output data rate to the spacecraft.
GLMSOW187	4.3.3.8.0-5	The Contractor shall define, size, and develop a design and specification for the software that will be developed for the instrument in the implementation phase, including flight, integration and test and simulation software.
GLMSOW188	4.3.3.9	4.3.3.9 Software
GLMSOW189	4.3.3.9.0-1	The Contractor shall define the software architecture for the GLM instrument that includes flight software, ground system software for instrument operation and test.
GLMSOW190	4.3.3.9.0-2	The Contractor shall define the software functions and processes and include estimates for software lines of code (SLOC) with estimates for new, modified and any re-use SLOC.
GLMSOW191	4.3.3.10	4.3.3.10 Detectors
GLMSOW192	4.3.3.10.0-1	The Contractor shall develop a design concept for the focal plane proposed for the Concept Design.
GLMSOW193	4.3.3.10.0-2	The Contractor shall provide an estimate of detector performance required to meet instrument requirements, including a detailed analysis of detector performance as a function of detector temperature and temperature stability under all operational cases, including normal solar passage through the field-of-view.
GLMSOW194	4.3.3.10.0-3	The Contractor shall corroborate the detector performance assessments, and the proposed designs of focal plane cooling (if applicable), and thermal control systems, through comparison to data from similar FPA hardware that has been validated through laboratory testing, thermal vacuum testing or flight.
GLMSOW195	4.3.3.10.0-4	The Contractor shall evaluate the impact of defective detector elements on FPA performance, and assess the allowable number of defective elements.
GLMSOW196	4.3.3.10.0-5	The Contractor shall define the measurement techniques and decision criteria used to classify detector elements as defective, and the techniques and algorithms required to minimize the degradations.
GLMSOW197	4.3.3.10.0-6	The Contractor shall develop a plan to mitigate risk during implementation of the GLM FPA concept design in accordance with Section 4.4.5.
GLMSOW198	4.3.3.11	4.3.3.11 Reliability and Lifetime
GLMSOW199	4.3.3.11.0-1	The Contractor shall perform a preliminary reliability analysis to demonstrate that the conceptual design can meet its required lifetime.
GLMSOW200	4.3.3.11.0-2	The Contractor shall identify all single point failure and fault critical elements.

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GLMSOW201	4.3.3.11.0-3	The Contractor shall describe the fault tolerant/graceful degradation features of the design.
GLMSOW202	4.3.3.12	4.3.3.12 Verification and Testing
GLMSOW203	4.3.3.12.0-1	The Contractor shall develop a draft System Performance Verification Plan in accordance with the IMAR, and that addresses verification of both the prototype model and flight model instruments. The Plan includes both performance verification and environmental verification. The definition of the prototype model is provided in Appendix A.
GLMSOW204	4.3.3.13	4.3.3.13 Ground Support Equipment
GLMSOW205	4.3.3.13.0-1	The Contractor shall identify the GSE for use during instrument development, spacecraft integration and test and at the launch site, including a description of all hardware, software, tooling, handling and logistical components.
GLMSOW206	4.3.4	4.3.4 Technology Assessment and Demonstration
GLMSOW207	4.3.4.0-1	The Contractor shall finalize, at or before the FPCCR, the assessment of technology readiness for GLM implementation. The minimum acceptable technology readiness criterion is defined as Technology Readiness Level TRL 6 (i.e., system or sub-system prototypes or models have been successfully tested under space conditions, either in space or on the ground) by the Implementation Phase PDR.
GLMSOW208	4.3.4.0-2	The Contractor shall evaluate existing technologies currently available and potentially suitable to the Concept Design drawing on current instrument and current instrument development (e.g., LIS on TRMM, LMS, and TBD).
GLMSOW209	4.3.4.0-3	The Contractor shall clearly identify and justify any technology validation that is expected to continue into the implementation phase.
GLMSOW210	4.3.4.0-4	The Contractor shall address risks associated with delayed validation in the Risk Management Plan.
GLMSOW211	4.3.4.0-5	The Contractor shall demonstrate through breadboards, prototypes, and similar validation techniques that all required technologies can be brought to TRL 6 by the required time.
GLMSOW212	4.3.4.0-6	A TRL Definition Table is provided in Appendix B.
GLMSOW213	4.4	4.4 Project Management
GLMSOW214	4.4.0-1	The Contractor shall develop a draft Project Management Plan (PMP) for the Implementation Phase of GLM development to include projections for the complete development and operation of the GLM Instrument.
GLMSOW215	4.4.1	4.4.1 Project Planning and Control
GLMSOW216	4.4.1.0-1	The Contractor shall provide a draft Work Breakdown Structure (WBS) for implementation by the MTR.
GLMSOW217	4.4.1.0-2	The Government will review and establish a Contract WBS for implementation.
GLMSOW218	4.4.1.0-3	The Contractor shall provide cost estimates for implementation, to level four of the WBS, that address both absolute costs (the achievement of a specific performance) and relative costs (the cost delta between required performance and the Contractors proposed design performance).
GLMSOW219	4.4.1.0-4	The Contractor shall define the cost estimation techniques that will be used during formulation to provide a preliminary cost estimate for the Concept Design by the MTR, and a final cost estimate for the concept design at the FPCCR.

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GLMSOW220	4.4.1.0-5	The Contractor shall perform cost analyses in support of all other trade studies and analyses required during the study period.
GLMSOW221	4.4.1.0-6	The Contractor shall perform time-phased cost analyses for development and production of four GLM flight models, one GLM prototype model and engineering units intended for risk mitigation.
GLMSOW222	4.4.1.0-7	The Contractor shall separately identify costs for unique GSE required for instrument procurement, fabrication, integration and test, calibration, spacecraft-level integration and test, and launch and on-orbit checkout activities, including logistics.
GLMSOW223	4.4.1.0-8	The Contractor shall provide a draft Implementation Phase schedule by MTR, showing PDR, CDR, completion of the engineering units and the prototype model, and delivery of the four flight models.
GLMSOW224	4.4.1.0-9	The Contractor shall refresh their draft Implementation Phase schedule at subsequent reviews.
GLMSOW225	4.4.2	4.4.2 Supplier and Subcontractor Control
GLMSOW226	4.4.2.0-1	The Contractor shall define and document a Supplier and Sub-Contractor Management System, which shall be part of the PMP.
GLMSOW227	4.4.2.0-2	The Contractor shall recommend a parts procurement strategy that addresses procurement of long-lead items and impact of late delivery on the implementation schedule.
GLMSOW228	4.4.3	4.4.3 Configuration Management
GLMSOW229	4.4.3.0-1	The Contractor shall define a Configuration Management System (CMS) for the complete life cycle of the GLM development.
GLMSOW230	4.4.4	4.4.4 Financial Management
GLMSOW231	4.4.4.0-1	The Contractor shall define the Financial Management System to be used for implementation that includes a Performance Measurement System with Earned Value, Cost Variance and Schedule Variance reporting to provide cost and schedule management for the entire life cycle of the GLM instrument program.
GLMSOW232	4.4.5	4.4.5 Risk Management
GLMSOW233	4.4.5.0-1	The Contractor shall identify and assess risks to the development of the GLM.
GLMSOW234	4.4.5.0-2	The Contractor shall use Failure Mode Effects Analysis (FMEA), Fault Tree Analysis (FTA), and Failure Mode Effects and Criticality Analysis (FMECA), as appropriate, to analyze and/or identify system and/or component risks.
GLMSOW235	4.4.5.0-3	The Contractor shall identify and prioritize the technical and programmatic risks that represent the greatest threat to the program.
GLMSOW236	4.4.5.0-4	The Contractor shall implement the actions (mitigate, watch or research) necessary to eliminate or reduce the likelihood or consequences of the identified risks and identify alternate implementation paths.
GLMSOW237	4.4.5.0-5	The Contractor shall identify risks in the Concept Design and address them at the FPCCR.
GLMSOW238	4.4.6	4.4.6 Contamination Control

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GLMSOW239	4.4.6.0-1	The Contractor shall develop a Contamination Control Program to ensure that the GLM instrument is not contaminated by molecular and particulate contaminants, both on the ground and on-orbit, to an extent sufficient to cause degradation of performance below the required levels.
GLMSOW240	4.4.7	4.4.7 Magnetic Control
GLMSOW241	4.4.7.0-1	The Contractor shall develop a Magnetic Control Program to ensure that GLM magnetic fields comply with limits set in the GLM PORD.
GLMSOW242	4.5	4.5 Mission Assurance
GLMSOW243	4.5.0-1	The Contractor shall develop a Mission Assurance Program for the implementation phase in accordance with the IMAR.

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GLMSOW244	5	5 Prototype Model Definition
GLMSOW245	5.0-1	The prototype model fully reflects the flight model design to the maximum extent possible. It has full redundancy and is fabricated with full reliability and quality control measures and flight EEE parts. The prototype model will be environmentally tested to full qualification levels and durations, and will be acceptance tested and fully calibrated in accordance with flight model test procedures. The prototype model will not be flown.

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GLMSOW246	6	6 Technology Readiness Levels
GLMSOW247	6.0-1	<p>TRL 1 Basic principles observed and reported: Basic scientific principles established. Initial translation to applied R&D. Mix of basic and applied research.</p> <p>TRL 2 Technology concept and/or application formulated: Identification of potential applications, in advance of experimental proof or detailed analysis. Mostly applied research.</p> <p>TRL 3 Analytical and experimental critical function and/or characteristic proof-of-concept: Laboratory studies to validate analytical predictions. <u>Scientific feasibility fully demonstrated.</u></p> <p>TRL 4 Module and/or subsystem validation in laboratory environment: Standalone prototype implementations. Experiments with integration of elements to validate system concepts.</p> <p>TRL 5 Module and/or subsystem validation in relevant environment: Significant improvement in fidelity of testing and integration. Prototype implementations conform to final environment. Experiments with realistic data. Simulated interfaces to existing systems.</p> <p>TRL 6 System/Subsystem prototype demonstration in a relevant end-to-end environment: prototype implementations on full scale realistic problems. Brassboard demonstrations in relevant environment (in space, if necessary). <u>Engineering feasibility fully demonstrated.</u></p> <p>TRL 7 System prototype demonstration in high-fidelity environment (parallel or shadow mode operation): Operational prototype, near or at the scale of the final system. Often done less for technology R&D than for system engineering and management confidence.</p> <p>TRL 8 Actual system completed and system “mission qualified” through test and demonstration in an operational environment: All functionality tested in operational scenarios through integration with existing systems. Verification and validation completed.</p> <p>TRL 9 Actual system “mission proven” through successful mission operations: Post implementation confirmation of system performance. <u>Actual system fully demonstrated.</u></p>

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GLMSOW248	7	7 Acronyms	
GLMSOW249	7.0-1	A/D ACA AI AIR CCP CMP CMS CONUS FMEA FMECA FMP FOV FPA FPCCR FTA FY GIRD GLM GPPPS GSE IV&V LDA LIS LMS MAID MAR MCP MTR NLT NPG NTE PDR PMP PORD PR R&D RFA RFI RMP SDP SEU SEL SEMP SEP SLOC SOW TBD TBR TBS TRL TS UIID VP WBS ZRDQ	analog-to-digital after contract award action item action item review contamination control plan configuration management system configuration management plan continental United States failure mode effects analysis failure mode effects and criticality analysis financial management plan field-of-view focal plane array formulation phase concept and cost review fault tree analysis fiscal year General Instrument Interface Document Geostationary Lightning Mapper government-provided physical parameter sheet ground support equipment independent verification and validation lightning detection algorithm Lightning Imaging Sensor Lightning Mapper Sensor master action item database Mission Assurance Requirements Document magnetic control plan mid-term review not later than NASA procedures and guidelines not to exceed preliminary design review project management plan Performance and Operational Requirements Document progress review research and development request for action request for information risk management plan software development plan single-event upset single-event latch-up systems engineering management plan systems engineering process source lines of code statement of work to be determined to be reviewed to be supplied technical readiness level trade study Unique Instrument Interface Document verification plan work breakdown structure zone of reduced data quality

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Attachment 1 Document Change Record

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